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APR 78 H O EBERHART, M SIMKO DAAK11-77-C-0112
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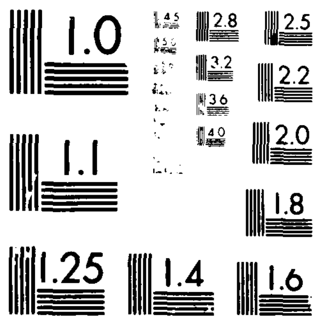

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

LEVEL II

POTOMAC RESEARCH, INCORPORATED
McLean, Virginia 22102

ADA084879

SPECIAL TECHNICAL REPORT IR 78.02 (APRIL 1978)

INSTALLATION RESTORATION COMPUTER PROGRAMMING REQUIREMENTS

Prepared For:

Department of the Army
Chemical Systems Laboratory
Development Support Division
Scientific & Engineering Applications Branch

Task: 01
Contract Number: DAAK11-77-C-0112
Installation Restoration Data Base Management

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Descriptions of computer programming requirements to support the Department of the Army's Installation Restoration Program. The assumptions used in this study were: 1) Record formats (tier 2) as specified in IR Data Management User's Guide will be used as input files until a Data Base Management System is established; 2) Output formats will be equally adaptable to the Univac 1108/CalComp combination and the Tektronix 4051 screen and 4662 plotter; 3) If a requirement of one installation can be of use to another installation, then the requirement will be generalized; and (continued)

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20. (continued) 4) Programs already available on the Univac 1108 computer at the central site will be preferred to those available elsewhere.

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APPENDICES

1. INTRODUCTION

This final report represents the results of Task 01 in the Installation Restoration (IR) program; namely, to determine computer programming requirements of all IR users. The assumptions used in this study were the following:

- Record formats (tier 2) as specified in IR Data Management User's Guide will be used as input files until a Data Base Management System is established.

- Output formats will be equally adaptable to the Univac 1108/CalComp combination and the Tektronix 4051 screen and 4662 plotter.

- If a requirement of one installation can be of use to another installation, then the requirement will be generalized.

- Programs already available on the Univac 1108 computer at the central site will be preferred to those available elsewhere.

The following sections will describe the computer programming requirements in such detail that these pages may serve as initial functional specifications for the programmer. Please note that these requirements were developed during the period of November 1977 through April 1978 and that other requirements will arise from time to time in the IR program; hence, consider this special technical report as only a first and necessarily incomplete effort.

2. METHODOLOGY

The task was started by examining a list of known requirements for computer programs developed by the Project Manager, Chemical Demilitarization/Installation Restoration (PM, CDIR). Next, a search was made in these software catalogs for applicable programs:

- ARRADCOM Edgewood Area U1108 User's Directory
- Univac 1100 Summary of Current Documentation, UP-7893
- NTIS Federal Software Exchange Catalog
- WES Engineering Computer Programs Library Catalog
- Business Automation Reference Service Computer Software, 2 Vols.
- Collected Algorithms of the ACM
- Datapro Directory of Software, 2 Vols.

If time permitted, the computer programs were tested on the Univac computer. At the same time a letter was mailed to all interested users in order to solicit their requirements. A sample letter appears in Appendix B.

Requirements received were checked for duplication and then processed through the above search procedure. As a result each validated requirement was rated as follows:

- completely satisfied by an available program
- partially satisfied by an available program
- no program located
- unable to define requirement now

3. COMPUTER PROGRAMMING REQUIREMENTS

3.0 Overview

Forty-five original computer programming requirements were identified as a result of our efforts in Task 01. Through consolidation thirty-seven requirements remain. A breakdown of the requirements by technological area is as follows:

	Number	%
• Chemistry	12	32
• Ecology	2	5
• Geology	15	41
• Other	8	22

Of the type of output format desired, almost 60% is to be graphic as opposed to printed.

Each requirement is discussed in detail in sections 3.1 through 3.37. One requirement may represent one or more computer programs, or it may be a simple checkout of an existing program. A uniform format is followed for each requirement: title, requester, input, processing, output, discussion, references. Input formats are in the IR Data Management User's Guide. References can be found in Appendix A. Abbreviations used are the following:

BIO US Army Medical Bioengineering Research & Development Laboratory, Ft. Detrick

ETD Environmental Technology Division, Chemical Systems Laboratory, Aberdeen Proving Ground

PB Pine Bluff Arsenal

PMO Project Manager, Chemical Demilitarization and Installation Restoration, Aberdeen Proving Ground

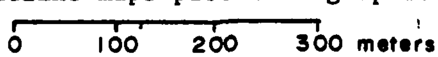
QA Quality Assurance Laboratory, Aberdeen Proving Ground

RM Rocky Mountain Arsenal

S&E Scientific & Engineering Applications Branch, Developmental Support Division, Chemical Systems Laboratory, Aberdeen Proving Ground

WES Waterways Experiment Station, Vicksburg

Note: 1. On all outline maps produce a graphic scale such as:



2. Parenthesized words written in capital letters and appearing after input file names are record keys.

3. An excellent source of information on the meaning of scientific terms is reference 26 in Appendix A.

3.1 Bore Hole - Elevation and Intervals Point Plot

Requester: WES

Input: Field drilling file (BORE)
Geotechnical map file
Geotechnical origin file

Processing: Read field drilling file to select bore holes and then plot their locations, elevations of tops of intervals, and thickness (to the right of elevation in parentheses).

Output:

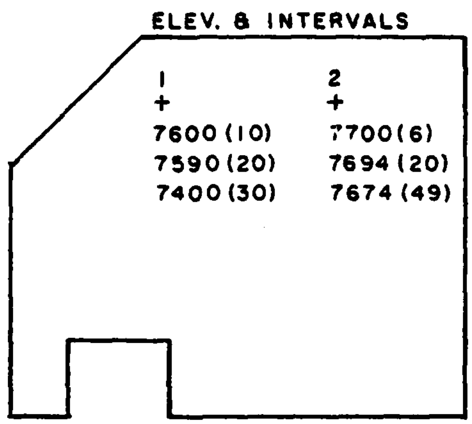


Figure 1. Outline Map

Discussion: Requirement 3.1 is partially satisfied by CalComp general routines AXIS, LINE, PLOT, SYMBOL, which are available at the central site. A program must be written using these routines to plot the bore holes and to draw the outline map.

Reference: 5

3.2 Bore Hole - Hydraulic Pressure

Requester: WES

Input: Field drilling file (BORE)

Processing: Read field drilling file to select bore holes and then plot elevations of tops of intervals and hydraulic pressures on the vertical axis.

Output:

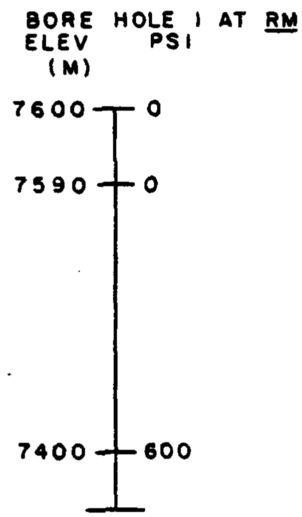


Figure 2. Bore Hole Hydraulic Pressure

Discussion: Requirement 3.2 is partially satisfied by CalComp general routines AXIS, LINE, PLOT, SYMBOL, which are available at the central site. A program must be written to draw the axis to scale.

Reference: 5

3.3 Bore Hole - Hammer Blows

Requester: WES

Input: Field drilling file (BORE)

Processing: Read field drilling file to select bore holes and then plot elevations of tops of intervals and number of hammer blows on vertical axis.

Output:

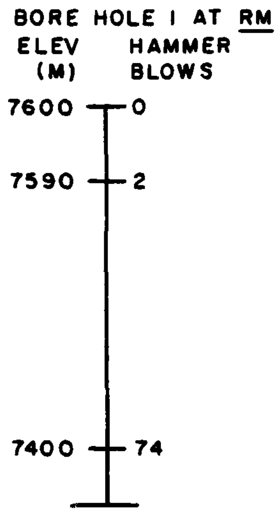


Figure 3. Bore Hole Hammer Blows

Discussion: Requirement 3.3 is partially satisfied by CalComp general routines AXIS, LINE, PLOT, SYMBOL, which are available at the central site. A program similar to requirement 3.2 must be written to draw the axis to scale.

Reference: 5

3.4 Bore Hole - Combination Elevation Contour Plot

Requester: WES

Input: Field drilling file (BORE)
Geotechnical map file
Geotechnical origin file
Run parameters - combination of two coded measurements; e.g.,LITHL/COLOR

Processing: Read field drilling file to select bore holes and then plot elevations of tops of intervals at which the combination of measurement and entry occurs.

Output:

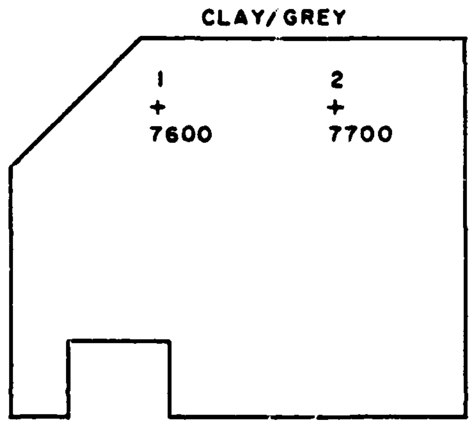


Figure 4. Outline Map

Discussion: Requirement 3.4 is partially satisfied by CalComp GPCP (General Purpose Contouring Program), which must be purchased by the central site. Although this requirement could be met with simpler software, it is recommended that GPCP be used because GPCP can accomplish requirement 3.5 by changing a parameter card. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Reference: 18

3.5 Bore Hole Combination Elevation Contour Plot

Requester: WES

Input: Field drilling file (BORE)
Geotechnical map file
Geotechnical origin file
Geotechnical elevation file
Run parameters - combination of two coded measurements; e.g., LITHL/COLOR.

Processing: Read field drilling file to select bore holes and then plot elevations of tops of intervals at which the combination of measurement and entry occurs; last, plot the contours.

Output:

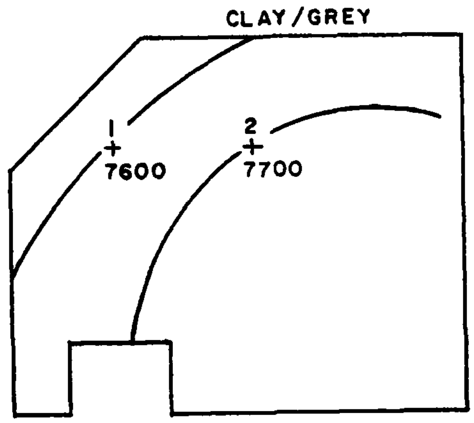


Figure 5. Outline Map

Discussion: Requirement 3.5 is partially satisfied by CalComp GPCP, which must be purchased by the central site. It is recommended that GPCP be purchased because it meets and exceeds all requirements in the IR program at a reasonable price. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Reference: 18

3.6 Bore Hole - Point Plot

Requester: WES

Input: Field drilling file (BORE)
Geotechnical map file
Geotechnical origin file

Processing: Read field drilling file to select bore holes and then plot their locations.

Output:

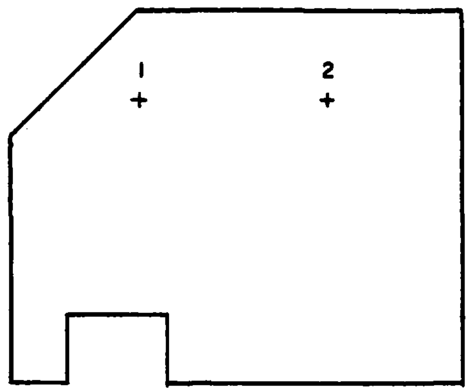


Figure 6. Outline Map

Discussion: Requirement 3.6 is partially satisfied by CalComp general routines AXIS, LINE, PLOT, SYMBOL, which are available at the central site. A program must be written using these routines to plot the points and to draw the outline map.

Reference: 5

3.7 Bore Hole - Profiles

Requester: PMO, PB, WES

Input: Field drilling file (BORE, WELL)
Geotechnical physical analysis file
Run parameters - order of bore holes
- vertical scale
- horizontal scale

Processing: Read field drilling file to select a bore hole or well. Accumulate information to plot a bar to scale by noting when a change in lithology or soil occurs. Save ground water level (stabilized) and depth to bedrock. Plot the bore hole profile; if another bore hole number is input as a run parameter, repeat the above and then draw lines connecting the ground water levels (∇) and connecting the bedrock levels (BR). Also read the geotechnical physical analysis file to determine whether there is more accurate information in this file to displace that information read from the field drilling file.

Output:

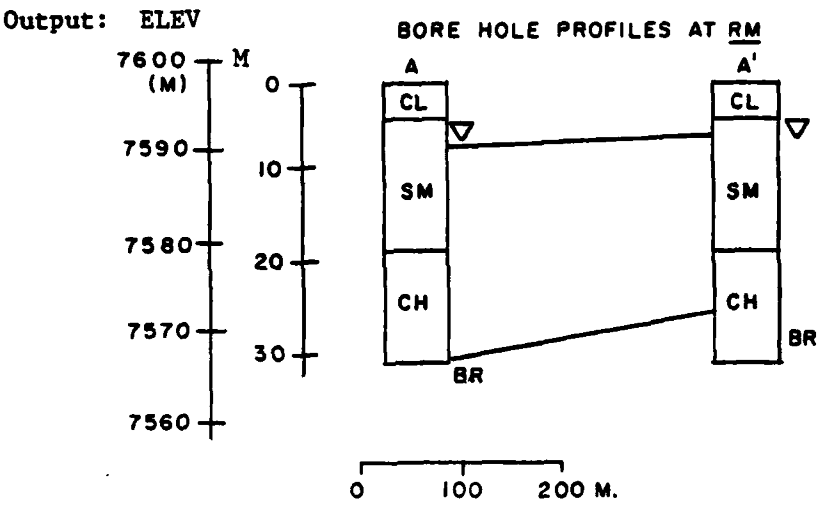


Figure 7. Bore Hole Profiles

Discussion: Requirement 3.7 is partially satisfied by the following:

Software	Language
BORE HOLE PROFILES	Tektronix BASIC
General Type Boring Log Plot	GE-400 Card FORTRAN

It is recommended that BORE HOLE PROFILES be adapted to Univac FORTRAN because the General Type Boring Log Plot is card-oriented toward a small operating system, uses card input incompatible with tier 2 files above, uses a different lithology coding scheme, and uses one GE assembly language routine SYMX.

References: 3, 16

3.8 Contaminant - Point Plot

Requester: PMO, PB

Input: Chemical Analysis file (TESTNAME)
Geotechnical map file
Geotechnical origin file

Processing: Read chemical analysis file to select contaminant (TESTNAME); then plot location and post concentration at that point.

Output:

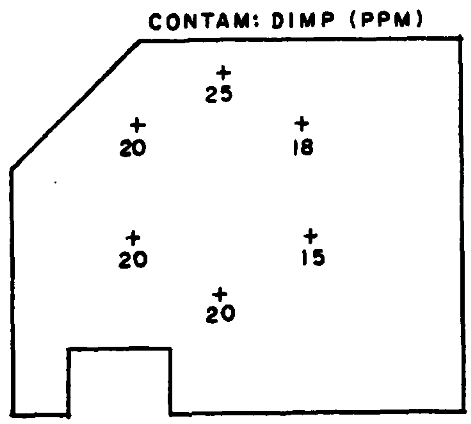


Figure 8. Outline Map

Discussion: Requirement 3.8 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Reference: 18

3.9 Contaminant - Contour Plot

Requester: PMO, PB

Input: Chemical analysis file (TESTNAME)
Geotechnical map file
Geotechnical origin file

Processing: Read chemical analysis file to select contaminant (TESTNAME); then plot location and post concentration at that point; last, plot the contours.

Output:

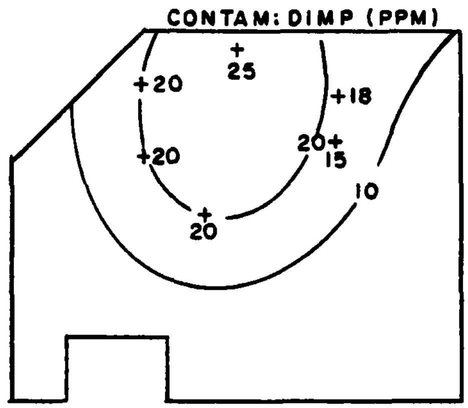


Figure 9. Outline Map

Discussion: Requirement 3.9 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

<u>Reference</u>: 18

3.10 Contaminant - Vertical Profile

Requester: PMO

Input: Chemical analysis file (TESTNAME)
Geotechnical map file
Geotechnical origin file
Geotechnical elevation file
Field drilling file
Run parameters - profile line end points 1 & 2
- depth < a
- maximum distance from profile line

Processing: Read map file to select sampling sites within maximum distance from the profile line; then read chemical analysis file to select contaminant (TESTNAME) depending on whether it is located on the profile line and whether it satisfies the depth condition.

Read field drilling file and elevation file to get surface elevations recorded within maximum distance from the profile line. Convert depth measurements to elevation above sea level. Plot topographic profile of surface between points 1 and 2; then plot location and post concentration at that point in relation to the axes; last, plot the contours.

Output:

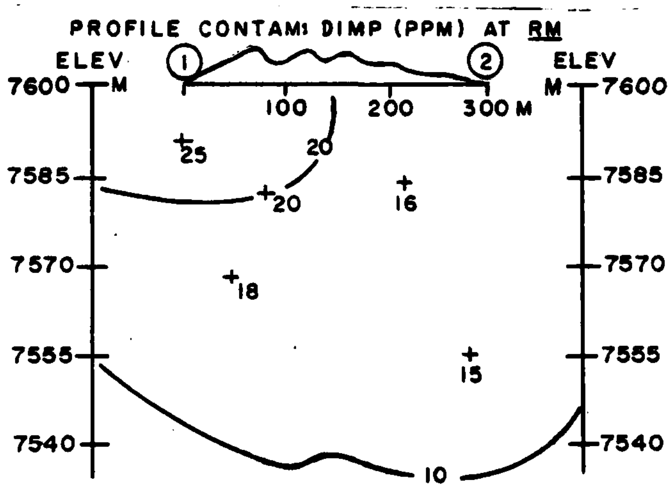


Figure 10. Contaminant Vertical Profile

Discussion: Requirement 3.10 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Programming Note: If it is known that the point R (x,y,z) lies on the profile plane, then its coordinates reduce to (p,z) where p is the distance from point 1 to point R; thus, a two-dimensional plot can be achieved.

Reference: 18

3.11 Contouring - Interpolation Method

Requester: RM

Discussion: For each contouring program adopted for the IR program, investigate the accuracy and options (if any) built into its interpolation method. A test surface whose contours are known may be used:

$$\left.\begin{matrix} 0 \leq X \leq 10 \\ 0 \leq Y \leq 10 \end{matrix}\right\} \quad (x-5)^2 - (y-5)^2 = 2(z-20)$$

The above surface has hyperbolas as contours.

References: 9, 18, 34, 42,43,44,45

3.12 Create Data Tape

Requester: PB

Input: Chemical analysis file (TESTNAME)
Geotechnical map file
Geotechnical origin file
Run parameters - Site ID
- a < measurement < b
- c < depth < d

Processing: Read chemical analysis file to select contaminant (TESTNAME), site ID, depth, measurement as specified in the run parameters; read geotechnical map file and origin file to get coordinates; then write these data on the output data tape.

Output: Tektronix 4051 Data Tape with records containing these fields: Site ID, TESTNAME, depth, coordinates, value of measurement. This tape will be used for statistical analyses conducted on the Tektronix 4051.

Discussion: No program was located. A program must be written to accomplish the above according to the following schema:

U1108 computer ⟶ 4051 data tape
(I/O address @33:)

Reference: 51

3.13 Coordinate Conversion

Requester: S & E

Input: Map coordinates in geographic, military, state planar, or Universal Transverse Mercator (UTM) format.

Processing: Depending on the spheroid, projection type, and coordinate type; convert one set of input coordinates to a set of output coordinates of a different type by means of the formulae of geodesy.

Output: Map coordinates converted to another format chosen from the list above.

Discussion: Requirement 3.13 is partially satisfied by all of the following software owned by the central site:

program D0154	State - Geodetic Coordinate Conversion
program J380	Geodetic - UTM Coordinate Conversion

A third program must be written to convert from military coordinates to one other type; then all three programs must be combined into a single set of subroutines.

References: 14, 30, 31

3.14 Correlation/Regression Analyses

Requester: PMO

Discussion: Correlation analyses such as the following are desired:

- Various variables including chemical analyses to other chemical analyses
- Chemical analyses in one medium to same chemical analyses in another medium
- Chemical analyses to population densities of certain ecological species
- Chemical analyses to soil types
- Chemical analyses to bedrock elevation

When correlation coefficients exceed given critical levels, regression will be used for further analysis. A preliminary analysis of available statistical software was conducted. OMNITAB II and SPSS were eliminated because these two packages have an unfamiliar language that must be learned quickly in order to use them. The following three packages were selected:

	Number of FORTRAN routines			
	Correlation	Regression	Anal. of Var.	Factor Anal.
BMDP	2	7	2	1
IMSL	7	22	20	11
U1108 STAT-PACK	1	2	13	1

Note: All of the above are available at the central site.

No judgement can be made on the merits of any one of these statistical packages until requirement 3.14 has been defined further.

References: 2, 15, 19, 21, 23, 27, 29, 32, 35, 37, 38

3.15 Explosive Hazard Analysis

Requester: ETD

Discussion: We are unable to define requirement 3.15 now; however, we should like to display explosive/contaminant hazard areas on an installation map. These hazard areas may result from accidental detonation during disarming operations.

<u>Reference</u>: None

3.16 Factor Analysis

Requester: RM

Discussion: Factor analysis is a multivariate statistical program obtained from a thesis prepared by a graduate student at State University of New York at Binghamton.

This program will compute:

- alpha factors
- iterated principal factors
- maximum likelihood factors
- principal components
- Rao's canonical factors

Factor loadings may be rotated to a target matrix according to one of these criteria:

- equimax
- oblique
- orthomax
- quartimax
- varimax

Requirement 3.16 is to convert this program from IBM FORTRAN to U1108 FORTRAN and then test it thoroughly.

Reference: 40

3.17 Food Chain - Pyramid of Numbers

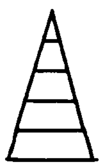
Requester: PMO

Input: Woodland vegetation file
Herbage vegetation file
Ecological general observations file
Run parameters - Section (0 = entire inst.)
- each pyramidal level (level code + Genus + Species)

Processing: Read level code and scientific name of species to establish the pyramid structure; next read woodland vegetation file (producers only), herbage vegetation file (producers only), and ecological general observations file to count the number of species located at that point or area. In the case of vegetation use 100 minus the weighted percent of bare ground or number of stems as the result; last, print the pyramid.

Output: Printout.

Pyramid of Numbers at RM Area: 01



Level	Species	Count or Coverage
C2	BUT JAM	7
C1	PER MAN	34
H	SPE SPP	2,001
P	BOU GRA	78.2%
P	BRO TEC	10.5%

Note: P - producer, H - herbivore, C - consumer
Number associated with level denotes order of the level.
Species codes - see reference 50 in appendix A.

Discussion: No program was located. A program must be written to accomplish the above by searching three input files and accumulating counts or percents of the species requested in the run parameter information. After a food chain has been established, the accumulation of contaminants in the ecosystem can be investigated through models such as those given in the references below.

References: 55, 58

3.18 Geophysical Test Results

Requester: WES

Input: Geotechnical physical analysis file (BORE, WELL)
Run parameters - physical test variables to print (codes)

Processing: Read geotechnical physical analysis file to select bore hole in combination with physical tests specified in the run parameter codes; then print the results.

Output: Printout.

PHYSICAL TEST RESULTS AT RM

Bore Num.	Sample Elev.(M)	USCS	Water Cont.(%)	Permeability (cm/sec)
1	7600	CL	5.0	1.0
1	7590	SM	2.5	4.6
1	7570	CH	1.0	0.01

Discussion: No program was located. A program must be written to accomplish the above by using codes in the run parameter information to decide which variables to print.

References: None

3.19 Ground Water Level - Point Plot

Requester: WES

Input: Field drilling file (BORE)
- GRDWS
Geotechnical map file
Geotechnical origin file

Processing: Read field drilling file to select bore holes; then plot their locations and the ground water level (stabilized).

Output:

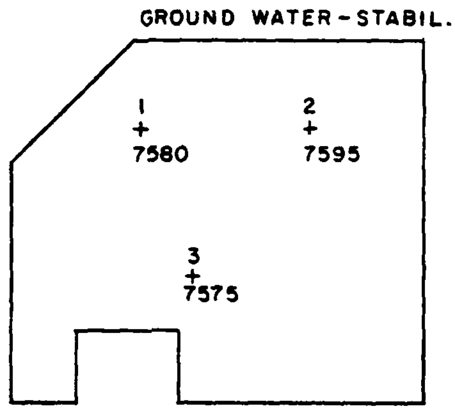


Figure 11. Outline Map

Discussion: Requirement 3.19 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Reference: 18

3.20 Ground Water Level - Contour Plot

Requester: WES

Input: Field drilling file (BORE)
- GRDWS
Geotechnical map file
Geotechnical origin file

Processing: Read field drilling file to select bore holes; then plot their locations and the ground water levels (stabilized); last, plot the contours.

Output:

GROUND WATER-STABIL.

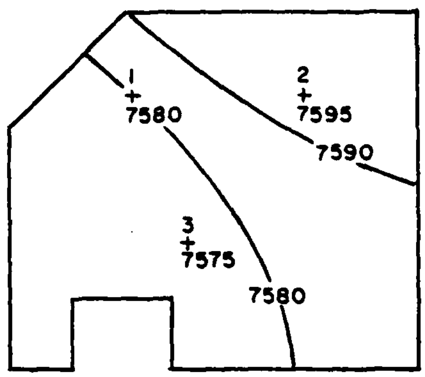


Figure 12. Outline Map

Discussion: Requirement 3.20 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Reference: 18

3.21 Ground Water - Flow Rate Computation

Requester: PMO

Discussion: We are unable to define requirement 3.21 pending the outcome of a meeting to be held at the Project Manager's Office during August 1978. The references listed below may be helpful.

References: 25, 28, 48, 59

3.22 Highest and 12-Month Average - Rocky Mountain Arsenal

Requester: PMO

Input: Chemical analysis file (TESTNAME = DIMP, DCPD & DBCP)
Geotechnical map file
Geotechnical origin file
Points 1, 2, ...n

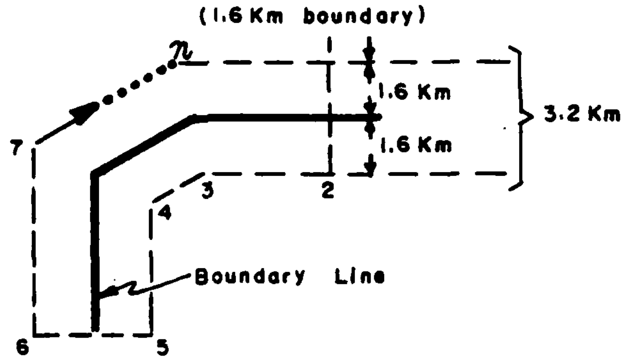


Figure 13. Boundary Points

Processing: Read chemical analysis file to select contaminant DIMP, DCPD, or DBCP; check to see whether the contaminated point lies within the polygon of Figure 13; if so, save the concentration to compute the highest concentration and the running average; last, print the report.

Output: Printout

RM ARS JUNE 19XX

CONTAM	HIGHEST CONC.(PPM)	12 MOS. RUNNING AVG. CONC.(PPM)
DIMP	44.4	55.5
DCPD	11.1	15.6
DBCP	10.0	14.4

Discussion: No program was located. A program must be written to accomplish the above by reading the chemical analysis file to get only DIMP, DCPD, and DBCP records.

Programming Note: Use algorithm 112 (from ACM) to check whether a selected point is within the given area of Figure 13, above.

Reference: 1

3.23 Highest 3 - Each Installation

Requester: PMO

Input: Standards chemical file (TESTNAME)
Chemical analysis file (TESTNAME)

Processing: For each chemical residing in the standards chemical file, search for the same chemical in the chemical analysis file and print the three highest concentrations, flagging those concentrations above the standard with an asterisk (*).

Output: Printout.

HIGHEST 3 CONCENTRATIONS AT INST: PB

STANDARD			OBSERVED		
CONTAM.	M	CONC. (PPM)	CONC. (PPM)	DATE	SITE ID
CLO5	W	5.5	11.1*	78365	1
			6.6*	78355	2
			3.3	78345	3
HH	W	1.25	0.99	78355	11
			0.88	78355	22
			0.77	78355	33

Similar printouts for all other installations.

Discussion: Requirement 3.23 is partially satisfied by program DIFF, which was developed at the Scientific and Engineering Applications Branch, Chemical Systems Laboratory, by Mr. W. K. Wallace. This program will have to be rewritten to accommodate changes in the output report format.

Reference: 12

3.24 Isopach Plot (Geological)

Requester: PMO

Input: Field Drilling file (BORE)
Run parameters - Site ID's (to define rectangle; if none use all of installation.)
- USCS or LITHL
- Depth $<$ a

Processing: Read field drilling file to select bore hole; record two elevations to tops of intervals at which a change in lithology or soil occurs in order to define the top and bottom of the stratum. Fit one surface to the top points and a second surface to the bottom points; subtract the values of the bottom surface from the values of the top surface and plot the contours of the residual surface.

Output:

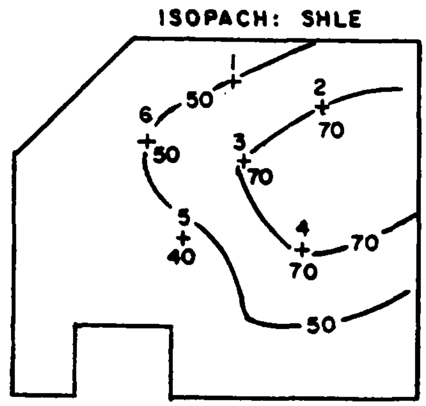


Figure 14. Outline Map

Discussion: Requirement 3.24 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. An input program must be written to format the input into an acceptable format for GPCP.

Reference: 18

3.25 List Data Tape

Requester: PB

Input: Tektronix 4051 Data Tape (output of section 3.12)

Processing: Read the input tape and write each record in column format on the Tektronix 4051 screen or line printer.

Output: Printout

DATA TAPE LISTING: PB

SITE ID	DEPTH	STATE PL. COORD		TEST NAME	MEASUREMENT
CA01222	600	11111	22222	P4	5.55 PPM
CA01333	610	33333	44444	P4	3.33 PPM

Discussion: No program was located. A program must be written in Tektronix BASIC to list the tape in the output report format, above. See also section 3.12.

Reference: 53

3.26 Model 1

Requester: PMO

Input: Coordinates, concentration, and time of deposit of point source of contaminant X located underground.

Subsurface water flow rates (from req. 3.21)

Terrain Geometry

Soil Characteristics

Processing: Unknown

Output: Concentration of X at subsurface points from time "0" to time "T".

Discussion: No program was located. Further systems analysis must be done to determine what programs are needed. The references below may be helpful.

References: 4, 22, 41, 55, 56, 60

3.27 Model 2

Requester: PMO

Input: Coordinates, concentration, and time of deposit of point source of contaminant X located on the surface.

Surface water flow rates (from req. 3.33)

Terrain geometry

Soil characteristics

Processing: Unknown.

Output: Concentration of X at surface points from time "O" to time "T".

Discussion: No program was located. Further systems analysis must be done to determine what programs are needed. The references below may be helpful.

References: 4, 41, 55, 56, 60

3.28 Model 3

Requester: PMO

Input: Concentration, natural decay rate, and time of deposit of contaminant X.

Amount of catalyst or microbe that is added to X

Processing: Unknown

Output: New decay curve of X for aerobic and anaerobic conditions. It may happen that this curve could be approximated by a combination of exponentials:

$$c_i e^{-k_i t} \quad [13: \text{ page } 15].$$

Discussion: No program was located. Further systems analysis must be done to determine what programs are needed. The references below may be helpful.

References: 4, 13, 58

3.29 Model 4

Requester: PMO

Input: Dispersion of contaminant X (from req. 3.26 or 3.27) located at point A.

Concentration, time of deposit of contaminant Y, whose chemical properties are perturbed from those of X.

Processing: Unknown.

Output: Concentration of Y at selected points from time "O" to time "T".

Discussion: No program was located. One approach to this problem might be to modify the program developed under requirements 3.26 and 3.27.

<u>Reference</u> : None

3.30 Quality Control

Requester: QA

Discussion: We are unable to define requirement 3.30 now; however, one workable approach to this requirement involves determination of certain limits derived from the calibration curve of an analytical procedure:

- detection limit (similar to type II statistical error)
- decision limit (similar to a type I statistical error)

Program DETECTION LIMIT has been written for the above [11].

Other approaches to quality control are contained in the references listed below. If a certain approach is decided upon, then its statistical assumptions must be thoroughly analyzed before any programming is done.

References: 11, 20, 33, 36, 49.

3.31 Queries - Chemical Analysis File

Requester: BIO

Input: Chemical analysis file (TESTNAME)

Queries such as --

1. At location A, list conc. of contaminant X
2. At location A, list all contam. whose conc. ε (c,d)*
3. At location A, rank 5 highest conc.
4. At location B, compute mean, standard deviation, 95% for all samples of contaminant Y

Processing: Search chemical analysis file using contaminant name as the key in order to accumulate the data to answer the posed question.

Output: Printout

1. At RM Location A
   CONTAM: X   CONC: 22 PPM

2. At RM Location A Conc. Range: 10 - 25 PPM

CONTAM:	CONC. (PPM):
AA	15.5
BB	22.2

3. At RM Location A

CONTAM:	HIGHEST CONC. (PPM):
CLO5	55
PP	44
PQ	33
HH	30
Y	27

4. At RM Location B
   CONTAM: Y
   MEAN 22.2   S.D. 3.3   95% C.I. 14.4-30.0

Discussion: Requirement 3.31 is completely satisfied by System 2000 Natural Language, which is part of System 2000 Data Base Management System available at the central site.

3.31 Queries - Chemical Analysis File (con't)

These queries could be formulated by using these Natural Language elements:

- PRINT with WHERE clause
- MAX
- AVG
- SIGMA
- User defined function to compute 95% confidence interval

Programming Note: The particular definition of "mean" that will be used must be thoroughly understood.

Reference: 46

---

* (c,d) is the interval of numbers X such that $c<x<d$

3.32 Species Distribution - Map Plot

Requester: PMO

Input: Ecological general observations file
Macroinvertebrate observations file
Ecological monitoring program file
Geotechnical map file
Geotechnical origin file
Run parameters - Section (0 = entire inst.)
- Date range
- Genus & Species

Processing: Read scientific name of species specified in the run parameters; next read the ecological general observations file, macroinvertebrate observations file, and ecological monitoring program file to count the number of species and assign the count to the correct location; last, decide on the density that each symbol will represent and plot the symbols to produce a dot map as described in reference 44.

Output:

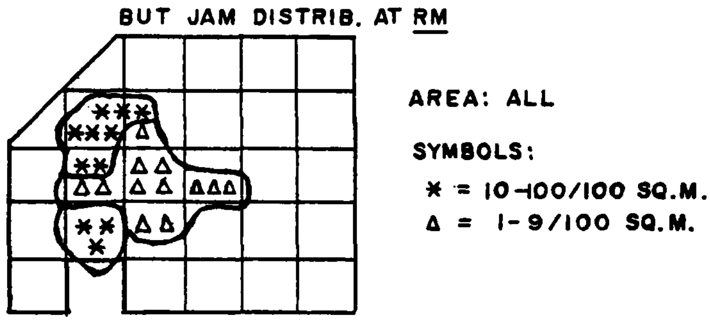


Figure 15. Outline Map

Discussion: Requirement 3.32 is partially satisfied by CalComp general routines or the SYMAP package, which is available at the central site. A program must be written using these routines to count the number of species within the section desired and then to plot a dot map; i.e., a nearest - neighbor map.

Programming Notes:

1. Sections must be stored on the geotechnical map file or in a special purpose file.

2. Use algorithm 112 (from ACM) to check whether a point is within a given section of Figure 15, above.

References: 1, 5, 44, 54, 57

3.33 Surface Water - Flow Rate Computation

Requester: PMO

Discussion: We are unable to define requirement 3.33 pending the outcome of a meeting to be held at the Project Manager's Office during August 1978. The agenda will address this requirement and requirement 3.21.

In the interim, requirement 3.33 may be partially satisfied by program KINGEN, which would have to be purchased from the US Department of Agriculture. Input to the program is the following:

- planes and channels: geometric properties measured from topographic map
- resistance parameters
- rainfall excess as a step function of time.

Output is an outflow hydrograph (simulated) at one point and computed outflows at planes and channels.

The other references listed below may be helpful.

References: 6, 24, 28

3.34 SURFACE II

Requester: RM

Discussion: SURFACE II is a computer graphics package from the Kansas Geological Survey; this software has the following capabilities:

- point plot
- contour plot
- three-dimensional perspective plot
- trend surface analysis
- directional derivative
- histogram

Requirement 3.34 is to install the U1108 version of this package and then test it thoroughly.

References: 42, 43

3.35 SYMAP and SYMVU

Requester: RM

Discussion: SYMAP is a computer graphics package from the Laboratory for Computer Graphics and Spatial Analysis, Harvard University; this software has the following capabilities:

- base map
- choropleth map
- contour map
- nearest-neighbor map
- trend surface
- residual map

SYMAP uses thirty-eight electives to effect map production; electives 30 through 37 control the interpolation algorithm.

SYMVU is a computer graphics package from the same distributor to produce three-dimensional plots of surfaces with a choice of projection:

- isometric
- two-point perspective
- planometric

Requirement 3.35 is to correct minor errors in the U1108 version of this package and to test all electives thoroughly.

References: 34, 44, 45

3.36 Water Contamination - Volume

Requester: PMO

Input: Saved Contaminant Contours (from req. 3.9)
Run parameters - Contour level polygon
- Saturated thickness
or
$depth_{WT}$, $depth_{BR}$ (for each well)
- % of moisture

Processing: Using the saved contaminant contours and the run parameters, the volume computation may be done in three steps:

1. Using the selected contaminant contour, set up the boundary in the xy-plane over which the integration will be done.

2. Approximate $depth_{WT}$ and $depth_{BR}$ with a least squares fit:

$$z_1 = depth_{WT} = a + bx + cy$$

$$z_2 = depth_{BR} = A + Bx + Cy$$

3. Compute the estimated volume of water contamination by approximating the double integral using a two-dimensional Simpson's rule [17].

$$V_w = \iint (z_2 - z_1) \; dx \, dy \;\; x \; (\% \text{ mois.})$$

Output: Printout

```
CONTAM:  DIMP    AT RM
CONTOUR LEVEL:  25 PPM
AREA:           1,000 SQ. M.
VOLUME:        15,555 CU. M.
ESTIM WATER CONTAM VOLUME:  785 CU. M.
```

Discussion: Requirement 3.36 is partially satisfied by CalComp GPCP, which must be purchased by the central site. See discussion in Appendix D. A program must be written to effect the above computation.

Note: Positive direction = down
Subscripts: BR = bedrock, WT - water table

<u>References</u>: 17, 18, 21, 47

3.37 Well Completion

Requester: WES

Input: Field drilling file (BORE, WELL)
Geotechnical map file
Geotechnical origin file

Processing: Read field drilling file to select bore hole or well and then plot elevation to top of interval at which measurement occurs (e.g., length of sand filter, SFILT) on vertical axis.

Output:

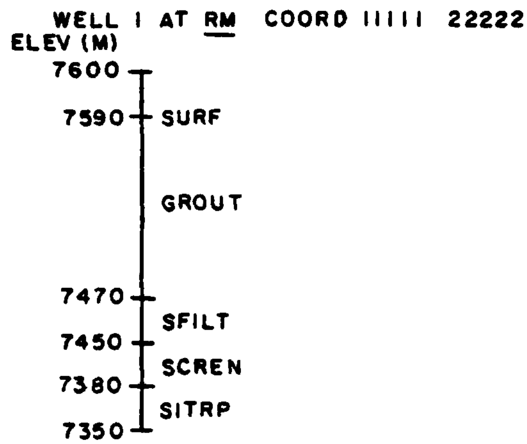


Figure 16. Well Completion

Discussion: Requirement 3.37 is partially satisfied by CalComp general routines AXIS, LINE, PLOT, SYMBOL, which are available at the central site. A program similar to requirement 3.2 must be written to draw the axis to scale.

Reference: 5

4. TEKTRONIX 4051 OPERATING SYSTEM

In developing the requirements of section 3, some problems arose concerning the 4051 microcomputer's operating system. Below is a schematic of the 4051.

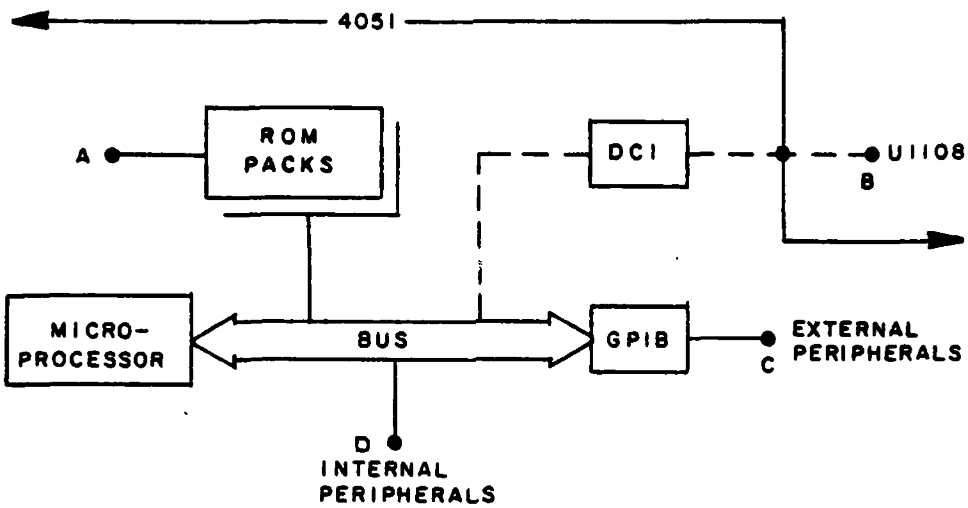


Figure 17. Tektronix 4051

The Data Communications Interface (DCI) allows the Univac computer to send data to the 4051 system, and vice versa. Two peripherals to which we desire output data to be delivered are the plotter and the line printer; hence, answers to the following questions must be found:

- How are these two peripherals connected to the 4051?
- What mode, BASIC I/O or terminal, is involved?
- Should a hardware or a software solution be attempted?
- What U1108 utility routines are needed?

Problem 1: Find a method of directing plotter output to the 4051 plotter.

Problem 2: Find a method of directing printer output to the 4051 line printer.

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APPENDIX A

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APPENDIX B

POTOMAC RESEARCH, INCORPORATED
7655 OLD SPRINGHOUSE ROAD
WESTGATE RESEARCH PARK
McLEAN, VIRGINIA 22101
703 790-5363

SAMPLE

Contract Number: DAAK11-77-C-0112
Installation Restoration Data Base Management

Dear Colleague,

At the present time we are collecting information from persons like yourself who are active in the Installation Restoration (IR) program in order to define your computer programming requirements.

Therefore, it is requested that you send these requirements to:

Potomac Research, Inc.
c/o Commander/Director
Chemical Systems Laboratory
ARRADCOM
Attn: DRDAR-CLJ-E
Aberdeen Proving Ground, MD 21010

Such requirements should include, but not be limited to, the following:

a. Input data requirements - Identify record types and data element names (variable names) in accordance with the IR Data Management User's Guide.

b. Processing required (if known) and references to the technical literature (if appropriate).

c. Output format desired - Graphic or tabular, output device preferred (remote terminal screen, remote line printer, remote cartridge tape drive, central site printer, central site tape drive, central site drum plotter). Sample output is highly desirable.

Please reply by 20 January 1978.

Sincerely,

APPENDIX C

Replies from Users

DEPARTMENT OF THE ARMY
US ARMY MEDICAL BIOENGINEERING RESEARCH AND DEVELOPMENT LABORATORY
FORT DETRICK, FREDERICK, MARYLAND 21701

IN REPLY REFER TO:
SGRD-UBG-T

4 January 1978

SUBJECT: Contract No. DAAK11-77-C-0112, Installation Restoration Data Base Management

Potomic Research, Inc.
c/o Commander/Director
Chemical Systems Laboratory
ARRADCOM
ATTN: DRDAR-CLJ-E
Aberdeen Proving Ground, MD 21010

1. In regard to the USAMBRDL IR program, we need to access data filed under SAMPLING AND ANALYSIS - CHEMICAL for use in standards development. Of particular interest would be the ability to derive some average contaminant mixtures, typical to Rocky Mountain Arsenal, for toxicity testing. At this time we anticipate the need to access concentration data for the following materials:

a. Water Contaminants

(1) by contaminant name
(2) by section number or other location identifier
(3) by well number or other source identifier
(4) by concentration range
(5) by concentration rank
(6) by date of file

b. Soil and Tissue Contaminants

(1) by contaminant name
(2) by medium
(3) by organism, if applicable
(4) by test site
(5) by concentration rank

SGRD-UBG-T 4 January 1978
SUBJECT: Contract No. DAAK11-77-C-0112, Installation Restoration Data Base Management

2. We will have the requirement to perform simple statistical analyses appropriate to determination of averages, and we envision tabular output to a remote terminal screen. I will be happy to further discuss our requirements at your convenience. The USAMBRDL Edgewood office (ext 2106) is open on Monday, Wednesday and Friday.

Dickinson Burrows

DICKINSON BURROWS
Tech Coord Ofc

DEPARTMENT OF THE ARMY
PINE BLUFF ARSENAL
PINE BLUFF, ARKANSAS 71611

SARPB-ETD 24 February 1978

SUBJECT: Data Requirements for Installation Restoration Program at Pine Bluff Arsenal (PBA)

Potomac Research, Inc.
c/o Commander/Director
Chemical Systems Laboratory
US Army Armament Research & Development Command
ATTN: DRDAR-CLJ-E
Aberdeen Proving Ground, MD 21010

1. Based upon your letter dated 16 December 1977 and a telephone conversation between Mr. H. O. Eberhart, CSL and Mr. Glen E. Murtha, PBA; the following information is forwarded as requested:

a. Input Data Requirements:

(1) The Data Management User's Guide, as revised in September 1977, identifies all record types and data element names expected for use by PBA with the following additions to the list of variable test names in the Sampling and Analysis-Chemical file:

BA = Barium	MPDDD = Meta Para DDD
PB = Lead	PPDDD = Para Para DDD
CS = CS	DYE = DYE
CN = CN	RDYE = Red Dye
DM = DM	YDYE = Yellow Dye
TDDT = Total DDT	VDYE = Violet Dye
HEX = Hexachloroethane	GDYE = Green Dye
OPDDD - Ortho Para DDD	MOIS = % Moisture

PBA currently has three categories of data being prepared for input into the TIER II IR files. These categories are:

(a) Chemical analyses data for the Contaminated Areas Survey at PBA. These data are currently stored in a data bank at the Northeast Computer Center (NECC), Fort Monmouth, New Jersey.

SARPB-ETD 24 February 1978
SUBJECT: Data Requirements for Installation Restoration Program at Pine Bluff Arsenal (PBA)

(b) DDT analyses data for the Contaminated Areas Survey at PBA. These data are currently stored in a TIER I IR file for verification and merging into TIER II with the other Contaminated Areas data.

(c) Chemical analyses data for the Geohydrology Study conducted by the Waterways Experiment Station, Vicksburg, MS. These data are currently stored in the HP3354 Laboratory Acquisition System at PBA in the IR format.

(2) Coordinates for the Contaminated Areas Survey at PBA are in a file on the U1108 and will be converted to a TIER I IR file.

(3) Coordinates for the Geohydrology Study will be keyed in manually into a TIER I IR file.

(4) Site identification (CC 16-25, left justified) data peculiar to these data in TIER II files will be as shown:

(a) Contaminated Areas: CAXXYYY
Where XX = Area Number on PBA (01-33)
YYY = Sample Number (1-999)

(b) WES Study: WESXXX
Where XXX = Well Number

b. Processing Required:

(1) Capability to retrieve sampling and analysis data from TIER II files by any specified variable name (Site ID, Sample depth, etc.) and create data tapes that can be used as input for statistical/engineering analyses.

(2) Capability to retrieve TIER II data and plot sample locations, contour lines for contaminants (actual concentrations, concentrations greater than a specified value, etc.), water levels in wells, well profiles, etc.

c. Output Format Desired (Examples):

(1) Tabular: PINE BLUFF ARSENAL
TYPE DATA (chemical) Date (DMMMYY)
FUNCTIONAL AREA: Sampling and Analysis

SITE ID	DEPTH	EW/NS GRID	TEST	Measurement (ppm/ppb/ppt)
CA/01/118	XXXX	XXXXX/XXXXX	OPDDT	X. XXXX ± XX

SARPB-ETD 24 February 1978
SUBJECT: Data Requirements for Installation Restoration Program at Pine Bluff Arsenal (PBA)

(2) Graphic: Contour mapping by concentration and coordinates with heading identifying Arsenal and contaminant and a legend giving specific identifiers.

d. <u>Input/Output Devices at PBA</u>:

(1) TEKTRONIX 4051 Graphic System

(2) TEKTRONIX 4662 Interactive Digital Plotter

(3) TEKTRONIX 4631 Hard Copy Unit

(4) TEKTRONIX 4641 Printer

(5) TEKTRONIX 4924 Digital Cartridge Tape Drive

(6) VERSATEC Plotter

(7) Data General C-330 Eclipse CPU w/7 and 9 Track Tapes, Disk Drive, Card Reader, Card Punch, Command Video Displays, Remote CRT and High Speed Printer.

(8) Centronics 530 Teleprinter

(9) Lear Siegler ADM II

(10) HP 3354

(11) Hazeltine 2000 w/ cassette tape and printer.

2. Pine Bluff Arsenal's point-of-contact is Mr. Glen E. Murtha, IR Project Officer, AUTOVON 966-2636.

FOR THE COMMANDER:

James L Bacon
JAMES L. BACON, PE
Director, Engineering & Technology

DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO 80022

SARRM-CC

22 February 1978

Potomac Research, Inc.
c/o Commander/Director
Chemical Systems Laboratory
ARRADCOM
Attn: DRDAR-CLJ-E (Mr. Simko)
Aberdeen Proving Ground, MD 21010

Dear Mr. Simko:

Reference is made to Rocky Mountain Arsenal (RMA) visit on 1-3 Feb 78 by Mr. Micheal Simko, PRI; Mr. Jerry Cichowicy and Lt James Wood, CSL; and undated letter from Potomac Research, Incorporated for the purpose of soliciting information regarding computer programming requirements.

In response to referenced requests, copies of the following were provided:

a. RMA 4051 Utility Programs
b. RMA 4051 Bore Profile Program
c. RMA 4051 Bore Profile & Chemical Plot Program
d. RMA 4051 $\bar{X}$&R Control Chart Program
e. RMA 4051 Statistical Test Program

RMA requested PRI/CSL to set-up and test the following:

a. Surface II Plot Program
~~b. WES General Boring Program~~

Program tape (9-track) and documentation for item a, and program documentation for item b were furnished. These routines will be utilized by RMA when ready.

c. Factor Analysis Program

Three boxes of punched cards were provided.

SARRM-CC
Mr. Simko

22 February 1978

Your support and cooperation in setting-up and making the programs in paragraph 3 operable will be greatly appreciated.

Sincerely,

Irwin M. Glassman

IRWIN M. GLASSMAN
Director, Contamination Control

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESSV

24 JAN 78

Potomac Research, Inc.
c/o Commander/Director
Chemical Systems Laboratory
ARRADCOM
ATTN: DRDAR-CLJ-E
Aberdeen Proving Ground, MD 21010

Gentlemen:

Reference your recent undated letter requesting computer programming requirements.

Computer programming requirements for our ongoing work at Pine Bluff Arsenal are inclosed (Incl 1). No other computer programming requirements for other IR ongoing work at our installation have been identified at this time.

Sincerely yours,

F. R. Brown

F. R. BROWN
Engineer
Technical Director

1 Incl
As stated

Copy furnished w/incl:
Project Manager, CDIR
ATTN: DRCPM-DRR/Al Shatto

SAMPLING AND ANALYSIS

Geo-Field Drilling

Input	Output	Exhibit
Grid location, bore hole	Graphic plot (GP), central site drum (CSD), plan view of bore holes	1
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement	GP, CSD, GRDWS* elevations	2
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement	GP, CSD, contour of GRDWS	3
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement, and length of interval	GP, CSD, sample elevations and interval	4
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement, and entry	GP, CSD, litho/color (or other combinations) elevations	5
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement, and entry	GP, CSD, contour of litho/color (or other combinations)	6
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement, and entry	GP, CSD, boring logs	7
Grid location, bore hole, elevation, depth to top of interval, date, action/measurement, and entry	GP, CSD, well completions	8
Grid locations, bore hole, elevation, depth to top of interval, date, action/measurement, entry, and selected azimuth, beginning coordinates, and maximum normal distance	GP, CSD, boring log profiles	9
Grid locations, bore hole elevation, depth to top of interval, date, action/measurement, entry, and selected boring numbers	GP, CSD, boring log profiles	10

*Groundwater level stabilized

(continued)

SAMPLING AND ANALYSIS (CONTINUED)

Geo-Field Drilling

Input	Output	Exhibit
Grid locations, bore hole, elevation, depth to top of interval, date, action/measurement, entry, and value	GP, CSD, hydraulic pressures	11
Grid locations, bore hole, elevation, depth to top of interval, date, action/measurement, and entry	GP, CSD, hammer blows	12

Geo-Physical Analysis

Input	Output	Exhibit
Data sheet	Tabular, central site printer, results (any combination)	13

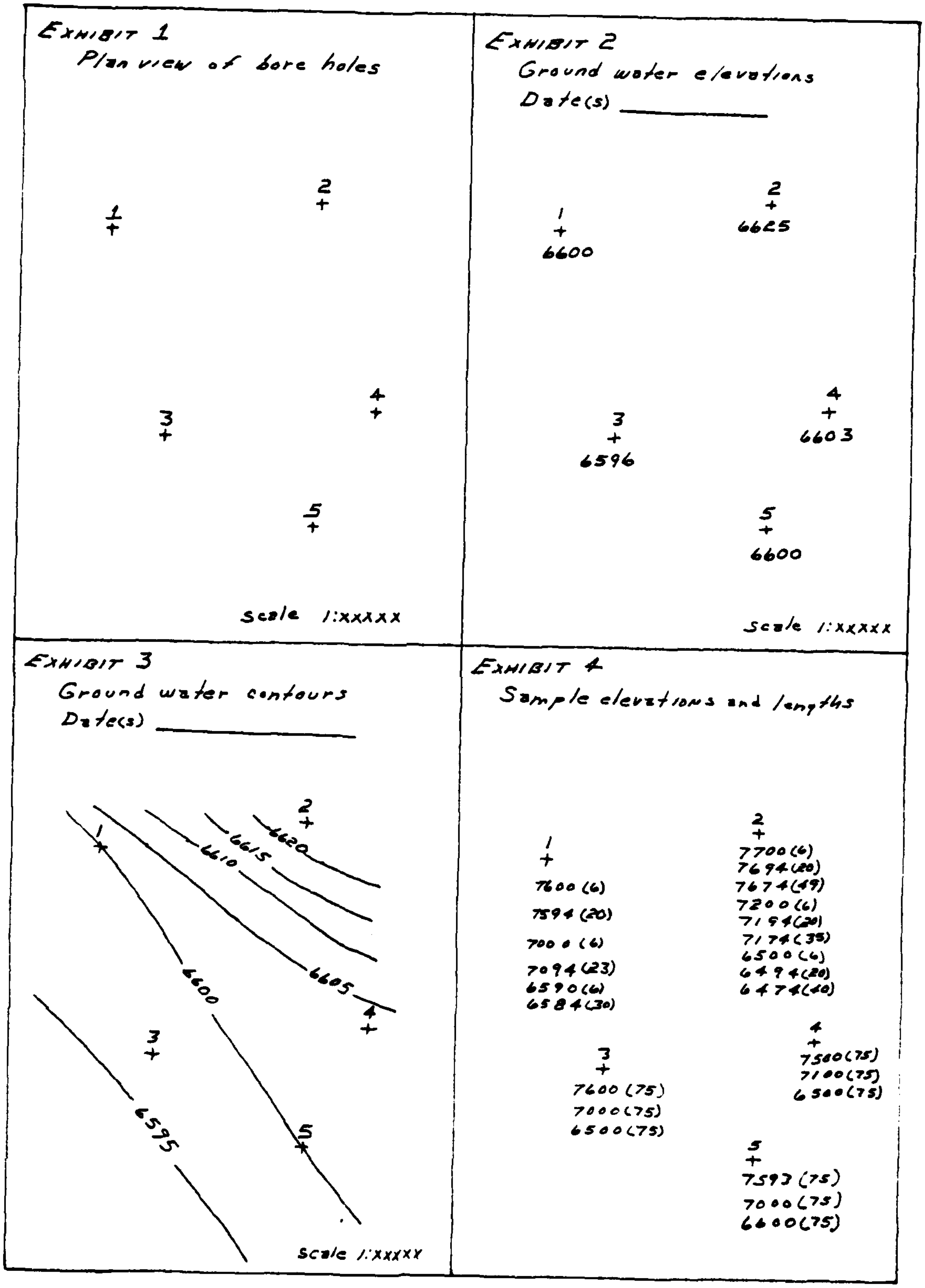
EXHIBIT 1
Plan view of bore holes
1
2
3
4
5
scale 1:XXXXX
EXHIBIT 2
Ground water elevations
Date(s)
1
6600
2
6625
3
6596
4
6603
5
6600
Scale 1:XXXXX
EXHIBIT 3
Ground water contours
Date(s)
1
2
3
4
5
6620
6615
6610
6605
6600
6595
Scale 1:XXXXX
EXHIBIT 4
Sample elevations and lengths
1
7600 (6)
7594 (20)
7000 (6)
7094 (23)
6590 (6)
6584 (30)
2
7700 (6)
7694 (20)
7674 (49)
7200 (6)
7194 (20)
7174 (35)
6500 (6)
6494 (20)
6474 (40)
3
7600 (75)
7000 (75)
6500 (75)
4
7500 (75)
7100 (75)
6500 (75)
5
7593 (75)
7000 (75)
6600 (75)

EXHIBIT 5

Action/measurement(s): LITHO, COLOR

Entries : CLAY, GRAY

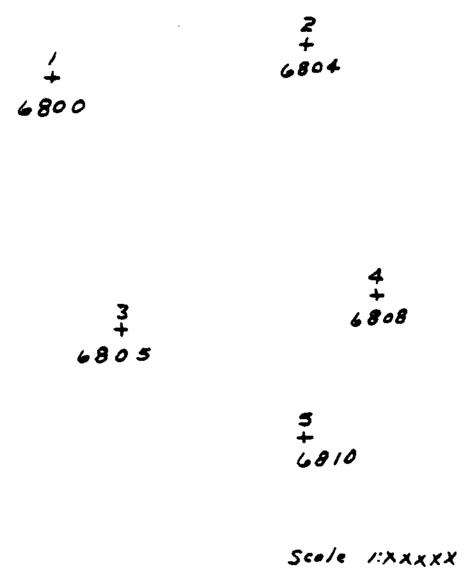

EXHIBIT 6

GRAY CLAY CONTOURS

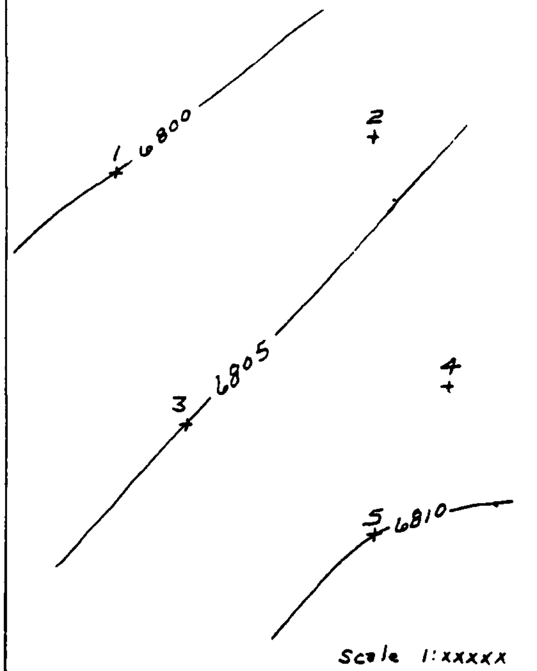

EXHIBIT 7

Boring Log

Boring No 1

Coord. xxxxx, yyyyy

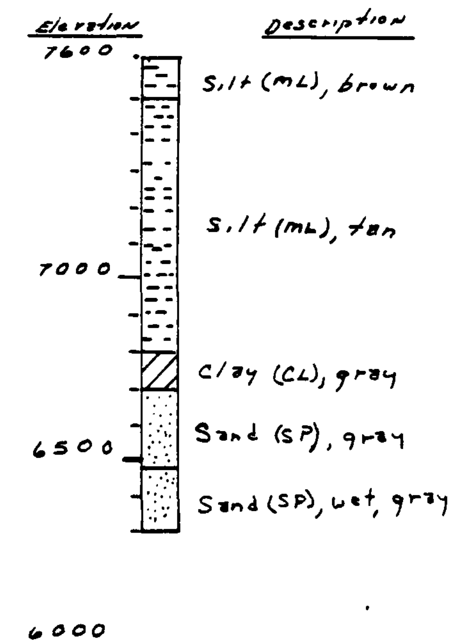

EXHIBIT 8

Well Completion

Boring No. 1

Coord. xxxxx, yyyyy

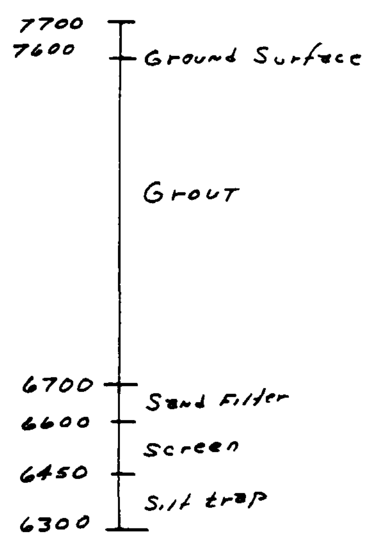

EXHIBIT 9

BORING LOG PROFILE

Azimuth: N 45° W   NORMAL TO AZIMUTH LIMIT: 200 metres

Initial Boring: 5

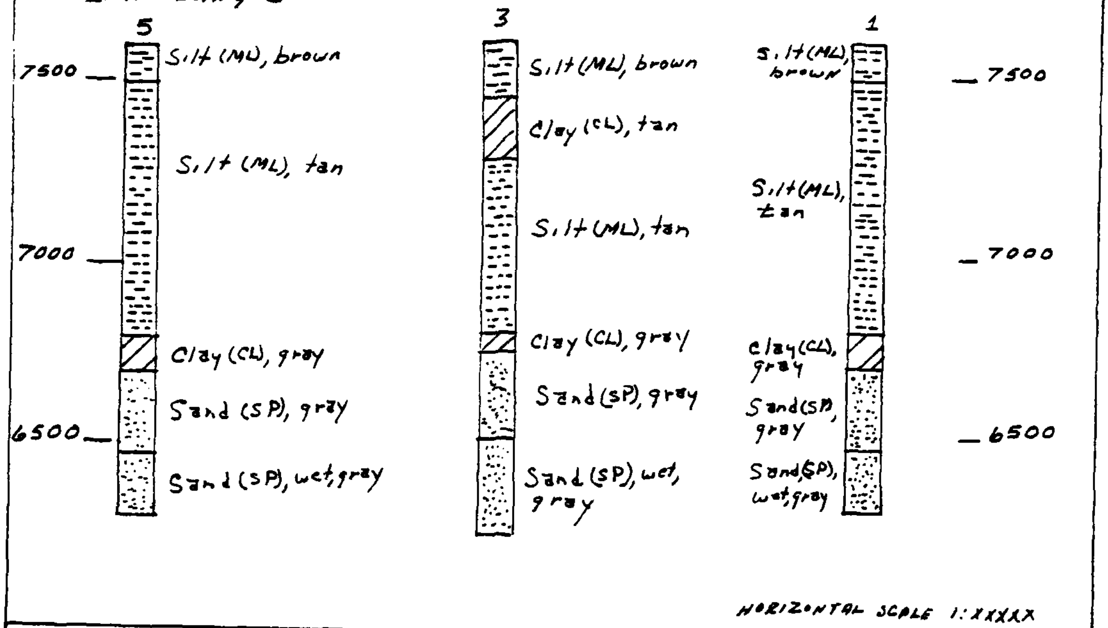

EXHIBIT 10

BORING LOG PROFILE

Boring sequence: 3, 5, 4

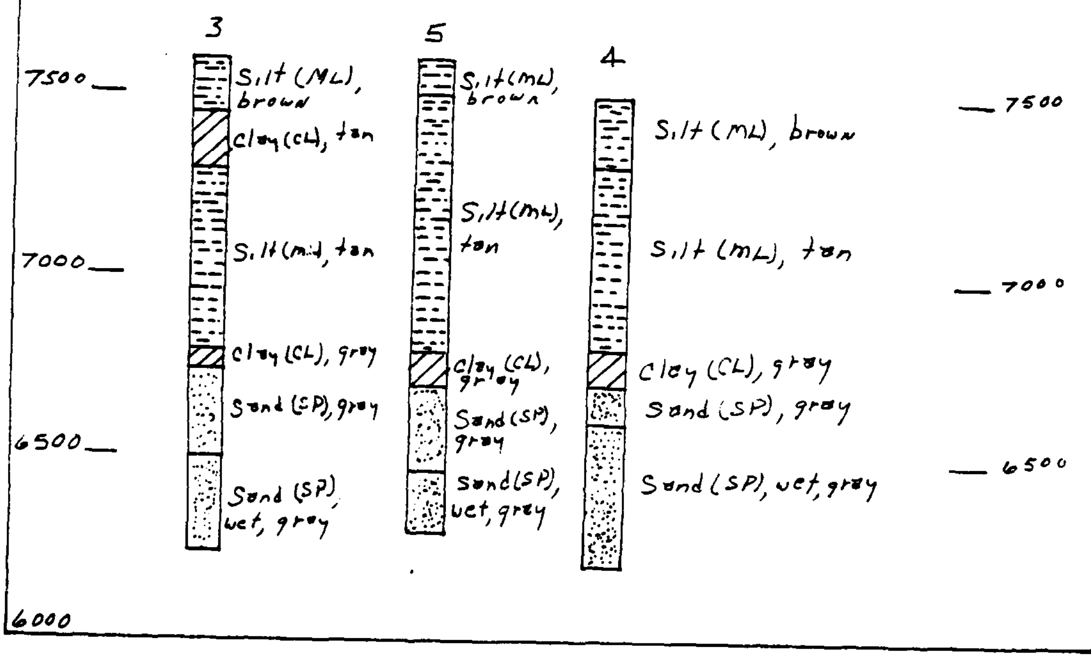

EXHIBIT 11
Hydraulic Pressures

3

Elevation	Pressure, psi
7600	0
7585	0
7570	50
7555	100
7540	400
7525	600
7000	0
6985	0
6970	100
6955	150
6940	150
6925	150

EXHIBIT 12
Hammer Blows

6

Elevation	Hammer Blows
7200	
7185	2
7170	2
7155	3
7140	1
7000	
6985	15
6970	20
6955	40
6940	50

EXHIBIT 13

PINE BLUFF ARSENAL
Physical Test Results

Boring No.	Sample Elevation, m	Liquid Limit	Plastic Limit	USCS Classification	Water Content, %	Dry Density, g/cc	Permeability Cm/sec	Percent Fines

APPENDIX D

Contouring Software Evaluation

by M.J. Simko

D.0 Overview

As required by task assignment number 01-7UR40C01-PD2 under contract number DAAK11-77-C-0112, a search of program libraries for existing programs to satisfy user requirements was initiated.

Since a large portion of the requirements concerned contour plots, the search concentrated on contouring programs.

After initial screening of programs at Aberdeen Proving Ground (Edgewood Area) and other program libraries, both Government and commercial, several programs were found that could partially satisfy presently known contouring requirements. Not all programs that were reviewed are discussed here; only those that satisfied several requirements.

D.1 Functional Requirements

Functions that are related to contouring and are essential to the IR Data Management Program are:

(1) Randomly spaced data. Because of the cost, the Installation Restoration project must necessarily limit the number and distribution of the geographical points at which samples are taken, relying on statistically sound sampling schemes rather than a "cover-the-world" approach. Although samples will be taken within a small gridded area carefully chosen because of anticipated high interest, these points will assume the appearance of a random distribution over an entire installation.

(2) Plotter display. To permit the immediate comprehension of the significance of IR data by both management and technical decision makers in the IR program, graphic display via plotter devices is essential. A large-scale drum-type CalComp plotter is available at the central site (Edgewood area of Aberdeen Proving Ground) that is capable of producing publication-quality plots, and each installation has been provided with Tektronix terminal equipment with the capability of producing graphic displays both on a cathode-ray (storage) tube and a small flat-bed plotter.

(3) Annotation. To understand fully the significance of any graphic display, it must be appropriately annotated to indicate such essential details as the value of the contour level, the value of the analysis of a sample at a specific point, the designation of the well or bore number, and the appropriate information in a legend to indicate what chemical analysis is represented, what time interval has been selected, what values are represented by the contour levels, etc.

Besides the above functions that are common to all plotting requirements, certain functions have been identified that are essential to one or more specific programming requirements. Most require the ability to mark the location of the data points that contribute to the data display (cf. 3.4, 3.5, 3.8, 3.9, 3.10, 3.19, 3.20, and 3.24). The capability to interpolate and/or extrapolate from data points that are known to other areas that are unknown and to plot curves that connect points of like value (contour plotting) is essential to several of the programming requirements (cf. 3.5, 3.9, 3.20, and 3.24). Requirement 3.10 needs the ability to display a profile; i.e., to plot a vertical cross section through one or several surfaces, displaying the values that characterize the surface(s). Two additional functions are required by Requirement 3.36: (1) computing the area bounded by contours and (2) computing the volume of soil, water, etc., and consequently the volume of a given chemical when the concentration of that chemical has been determined.

In summary, the functions required by a contouring program package are:

(1) Randomly spaced data input

(2) Plotter display

(3) Annotation

(4) Point plotting

(5) Contour plotting

(6) Vertical plotting

(7) Area computation

(8) Volume computation

D.2 Contouring Packages Considered

Programs located and found to meet several requirements are as follows:

CONTOUR by California Computer Products, Inc., 2411 West LaPalma Avenue, Anaheim, CA 92801, telephone # (714) 821-2011, has the capability to plot contours for seismic, demographic, geological, thermal, and pressure maps and diagrams from randomly spaced input data. (Price - $4,000)

CPS-1 by Unitech, Inc., 1005 East Saint Elms Road, Austin, TX 78745, telephone # (512) 444-0541, has the capability to plot contours from gridded or randomly spaced data points, profiles, isometric, and point-plot. (Price - $25,000 for total system)

SURFACE II by Robert J. Sampson, Kansas Geological Survey, 1930 Avenue "A" Campus West, Lawrence, KS 66044, is a large computer graphics system for manipulation and display of randomly spaced input data. Contour, point, trend surface, and perspective plots of irregularly spaced data can be produced on a plotter device. However, flexibility in producing

such things as physical landmarks (i.e., lakes, rivers, roads, etc.) and map legends on the plot is limited. Although SURFACE II has good accuracy in plotting contours, points, trend surface, and perspective plots, it does not fulfill requirements such as profile plot contamination, area of contamination, volume of contamination, geological strata plot, and bore hole plot. (Presently available)

SYMAP by Harvard University Laboratory for Computer Graphics, 48 Quincy Street, Cambridge, MA 02138, telephone # (617) 495-2526, has the capability to produce three basic types of maps on a line printer: contour, choropleth (conformant), and nearest-neighbor (proximal) plot. When combined with the added feature of SYMVU, it has the ability to generate a three-dimensional perspective view of a statistical "surface" on a line plotter; also SYMVU has the advantage that it accepts randomly spaced data values to construct a gridded, spatially continuous surface. (Presently in use on UNIVAC 1108)

GPCP by California Computer Products, Inc., 2411 West LaPalma Avenue, Anaheim, CA 92801, telephone # (714) 821-2011, can plot a map from parameterized data and has been used in varying applications to plot such things as seismic, demographic, geological, thermal, and pressure maps. This program uses a gridding method which automatically computes gridded data from randomly spaced input data, analytically constructing a smooth surface. The user input controls gridding and contouring to produce the desired maps over a range of data distribution. GPCP offers such features as the ability to produce stereo views, and to enter known gradients to increase accuracy. The user can save computer array values for further processing if the map exceeds the user specified plot size. GPCP automatically splits the map with a perfect match of contour lines between sections. Options available with GPCP include:

a. Integration for Surface Area and Volume which enables the user to determine net and gross volumes, as well as projected and surface areas of a function within a lateral boundary.

b. Straight-Line Cross-Section (profiling) which plots cross-sections through surfaces.

c. Additional Data Posting which adds several capabilites: to post up to five function (z axis) values at any size, angle or position; to use italic annotation; to use more symbols for center marks; to connect points with solid, dashed, or chained lines; and to alter contour values while posting additional data.

d. Trend Surface Analysis which generates the coefficients of a polynomial representing a surface.

e. Algorithmic Processor (Grid-To-Grid Operations) which permits a user to add, subtract, multiply, divide, compare, and set grids to high or low values and perform scalar operations on generated grids (Price - $15,000 including options)

D.3 Functional Capabilities of Contouring Packages

The following essential functional capabilities were found:

Software Package	Function
CONTOUR	Randomly spaced data input Plotter display Point plotting Contour plotting
SURFACE II	Randomly spaced data input Plotter display Point plotting Contour plotting
SYMAP-SYMVU	Randomly spaced data input Plotter display (as three-dimensional perspective only) Point plotting Contour plotting (on printer only)
CPS-1	(Further consideration discontinued because of price)
GPCP	Randomly spaced data input Plotter display Annotation Point plotting Contour plotting Vertical profiling Area computation Volume computation

D.4 Conclusions

As can be seen from the preceding sections, GPCP satisfies all the identified functional requirements of the Installation Restoration program. It is estimated that the level of effort needed to augment or modify any of the other packages would be at least one man-year at a cost in excess of $30,000.

D.5 Recommendations

It is recommended that GPCP (with options) be purchased by the Government for use in the IR program at an estimated cost of $15,000.